Spectral element modeling and kernel calculation for nearly constant Q media

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Seismic waves are subject to dispersion and dissipation when propagating through the Earth. Seismic attenuation and dispersion can be caused by various mechanisms, including partial melting within the crust and mantle, and presence of water in the mantle. Dispersion and attenuation can significantly influence the phases and amplitudes of recorded seismograms. Without considering these influences, we may get incorrect results when imaging the Earth's interior structure.

In this study, we derive a new wave equation for modelling viscoelastic wave propagation and calculate the sensitivity kernels in nearly constant Q media. In comparison to previous studies, the advantages of the proposed viscoelastic wave equation are: (1) the quality factor Q is explicitly incorporated in the wave equation, which facilitates the derivation of the sensitivity kernels for Q in full waveform inversion; (2) the proposed viscoelastic wave equation can be directly solved by using the spectral element method, which has lower computing cost than the one requires Fourier transform; (3) The relaxation time (weighting function) of the proposed viscoelastic wave equation is not influenced by the specific Q value but only depends on the selected frequency range.

The accuracy of the proposed viscoelastic wave equation is proved by comparing with analytical solutions and results from the GSLS method. Then, half space model is used to demonstrate that the proposed wave equation is useful for calculating sensitivity kernels in nearly constant Q media. With the accuracy of the viscoelastic wave simulation and lower computational costs, the proposed wave equation has great potential to be used in reverse time migration and viscoelastic waveform inversion.

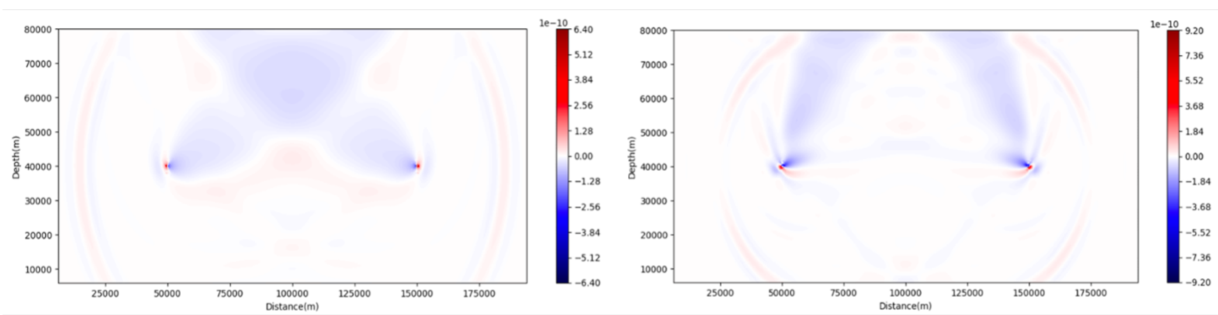

Figure 1. Sensitivity kernel of Q_p and Q_s using amplitude ratio misfit function.